



Code Compliance and Permitting and Inspections

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New Developments in Chicago Permitting
Overview and Standards for Permitting, Code Compliance
and Inspections

DER Road Show





PV Systems and the National Electrical Code[©]

- ◆ **Article 690** addresses safety standards for the installation of PV systems.
- ◆ Many other articles may also apply to PV installations:
 - Article 110: Requirements for Electrical Installations
 - Article 230: Disconnect Means
 - Article 240: Overcurrent Protection
 - Article 250: Grounding
 - Article 300: Wiring Methods
 - Article 480: Storage Batteries
 - Article 685: Integrated Electrical Systems
 - Article 705: Interconnected Electric Power Production Sources
 - Article 720: Circuits and Equipment Operating at Less than 50 Volts



PV System Code Compliance: Common Problem Areas

- ◆ Insecure structural attachment of PV arrays to rooftops and other structures (e.g., attachment of roof mounts directly to roof decking)
- ◆ Inadequate weather sealing for roof penetrations
- ◆ Unsafe wiring methods, insufficient conductor ampacity and insulation type
- ◆ Lack of or improper placement or ratings of overcurrent protection and disconnect devices
- ◆ Unsafe installation, improper use and maintenance for batteries
- ◆ Use of unlisted equipment or improper application of listed equipment
- ◆ Lack of or improper system grounding
- ◆ Lack of or inadequate labeling on major system components and disconnect devices
- ◆ Lack of or inadequate documentation on system design, and operating and maintenance requirements



Photovoltaic System Installation: Inspection Checklist

- ◆ Photovoltaic source and output circuit conductors shall not be run with other conductors **[690.4(B)]**
- ◆ Equipment shall be identified for use in solar photovoltaic systems **[690.4(D)]**
- ◆ DC ground fault protection shall be provided for PV arrays on dwellings **[690.5]**
- ◆ Alternating-current modules shall have appropriate markings, overcurrent protection, disconnect means and GF protection **[690.6, 690.52]**



Circuit Requirements for PV Systems: Inspection Checklist

- ◆ Maximum system voltage at lowest temperature shall be less than module maximum voltage rating (most modules listed for 600 volts) **[690.7]**
- ◆ Maximum system voltage shall be less than 600 volts for dwellings, over 150 volts accessible only to qualified persons **[690.7(C)(D)]**
- ◆ Module conductors should be rated for at least 90° C **[690.8(A)]**
- ◆ Photovoltaic source and output circuit conductors and overcurrent protection devices shall be sized for no less than $I_{sc} \times 1.25 \times 1.25$ **[690.8(B)]**
- ◆ Inverter output circuit conductors and overcurrent devices shall be sized for the inverter continuous output current rating **[690.8(A)(3)]**
- ◆ Stand-alone inverter input circuit conductors and overcurrent devices shall be sized for input current at rated output at lowest operating voltage $\times 1.25$ **[690.8(A)(4)]**
- ◆ Equipment and devices rated for 125% of maximum voltage



Overcurrent Protection for PV Systems: Inspection Checklist

- ◆ Photovoltaic source circuit, photovoltaic output circuit, inverter output circuit and storage battery circuit conductors and equipment shall be protected in accordance with Art. 240 **[690.9(A)]**
- ◆ Overcurrent protection shall be provided for power transformers in accordance with Art. 450.3 **[690.9(B)]**
- ◆ Branch-circuit or supplementary-type overcurrent devices shall be provided for photovoltaic source circuits, no greater than series fuse on module listing **[690.9(C)]**
- ◆ Overcurrent devices are listed for use in dc circuits and shall have the appropriate voltage, current and interrupt ratings **[690.9(D)]**
- ◆ No issues with multiwire branch circuits **[690.10(C)]**



Disconnect Means for PV Systems: Inspection Checklist

- ◆ Disconnect means shall be provided between photovoltaic power system output and other building conductors, no disconnect in grounded conductor. **[690.13(A)]**
- ◆ Photovoltaic disconnecting means shall be installed at a readily accessible location either outside of a building or structure or inside nearest the point of entrance of the system conductors (not in bathrooms) **[690.14(C)]**
- ◆ Each photovoltaic system disconnect means shall be marked, suitable for use, no more than six grouped disconnects for PV system **[690.14(C)]**
- ◆ Disconnect means shall be provided for inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources **[690.15]**



Disconnect Means for PV Systems: Inspection Checklist (cont.)

- ◆ Disconnecting means shall be provided to independently disconnect a fuse from all sources of supply if the fuse is energized from both directions **[690.16]**
- ◆ Switches or circuit breakers shall be provided to disconnect ungrounded conductors, are readily accessible, have on/off indication, and have appropriate interrupt rating **[690.17]**
- ◆ Energized disconnects in open position shall be labeled as such **[690.17]**



PV System Wiring Methods: Inspection Checklist

- ◆ Appropriate wiring methods shall be used **[690.31(A)]**
- ◆ Single conductor cables type SE, UF, USE, and USE-2 single-conductor are permitted in photovoltaic source circuits, sunlight resistant cable shall be used **[690.31(B)]**
- ◆ Flexible cords and cables, identified for hard service, outdoor and sunlight resistant are permitted for tracking or movable array mounts **[690.31(C)]**
- ◆ Single-conductor cables in sizes 16 AWG and 18 AWG shall be permitted for module interconnections where such cables meet the ampacity requirements of 690.8 **[690.31(D)]**
- ◆ Connectors permitted in Art. 690 shall be polarized, noninterchangeable, guarded, locking, and have first to make and the last to break contact for grounded conductor **[690.33]**
- ◆ Junction boxes **[690.34, 300-15, 370]**
- ◆ Conductors in systems operation 50 volts or less shall not be smaller than 12 AWG copper or equivalent **[720.4]**



Grounding in PV Systems: Inspection Checklist

- ◆ DC conductor shall be grounded at a single point for *two-wire* PV systems operating above 50 volts, center tap shall be grounded for bi-polar arrays. Disconnect switches shall not open-circuit the grounded conductor any time **[690.41]**
- ◆ DC grounding shall be made at any point on photovoltaic output circuit **[690.42]**
- ◆ Non-current-carrying metal components shall be grounded for all PV systems, including module frames, conduit and boxes as applicable **[690.43]**
- ◆ Equipment grounding conductor shall be sized for 125% of photovoltaic source and output circuit I_{sc} . **[690.45]**
- ◆ Where GFID is used per 690.5, equipment grounding conductor shall be sized according to **[250.122]**
- ◆ Grounding electrode system shall be installed **[690.47, Art. 250]**



Solar Photovoltaic System Markings: Inspection Checklist

- ◆ Photovoltaic modules shall be labeled with UL, series fuse requirement, V_{oc} , V_{op} , V_{max} , I_{sc} , I_{op} , P_{max} **[690.51]**
- ◆ Photovoltaic power source shall be labeled with I_{op} , V_{op} , V_{max} , I_{sc} at disconnect **[690.53]**
- ◆ Point of interconnection shall be labeled with Volts AC, max amps AC at disconnect **[690.54]**
- ◆ Energy storage (batteries) shall be labeled with V_{op} max, V_{eq} , polarity **[690.55]**
- ◆ Accessible notice and location of disconnect means shall be provided for stand-alone systems **[690.56]**
- ◆ Utility systems shall have location label if PV and service disconnect are not together **[690.56]**



Connection to Other Sources: Inspection Checklist

- ◆ Inverters shall be listed and identified for interactive operation **[690.60]**
- ◆ Interactive inverters shall de-energize when interactive source of power is lost **[690.61]**
- ◆ No unbalanced interconnections **[690.63]**
- ◆ Disconnect and overcurrent device for supply side interconnections **[690.64(A)]**
- ◆ Load side interconnections **[690.64(B)]**
 - Shall be made at dedicated branch circuit or fusible disconnect
 - Ampere rating of breakers feeding panel shall not exceed busbar rating (120% of busbar rating for dwellings)
 - Interconnection shall be on line side of any ground-fault protection equipment
 - Overcurrent devices supplying power to busbar shall be marked to indicate the presence of all sources of supply
 - Backfed breakers shall be identified



Batteries in PV Systems: Inspection Checklist

- ◆ Installation shall use appropriate racks, trays and ventilation [**480.8, 480.9, 480.10**]
- ◆ Operating voltage for dwelling less than 50 volts nominal - no more than 24 – 2-volt lead-acid cells in series [**690.71(B)**]
- ◆ Battery terminals and other live parts shall be guarded, adequate working space [**480.99(B),(C)**]
- ◆ Current-limiting fuses (types RK-5, RK-1, T) shall be installed on battery output circuits [**690.71(C)**]
- ◆ No conductive cases for batteries greater than 48 volts, nominal. Conductive racks permissible, must be at least 6” from top of battery case. [**690.71(D)**]
- ◆ Series disconnects shall be provided for battery strings over 48 volts, nominal [**690.71(E)**]
- ◆ Disconnect shall be provided for grounded conductor for battery systems over 48 volts, accessible only to qualified persons [**690.71(F)**]



Battery Charge Controllers: Inspection Checklist

- ◆ Battery charge control shall be used in any system where the charge rates are greater than 3% of battery capacity. Adjustment only accessible to qualified persons **[690.72(A)]**
- ◆ Systems using diversion charge controllers shall have secondary independent means for charge control. DC diversion loads, conductors and overcurrent devices must be rated for at least 150% of the controller current rating **[690.72(B)]**
- ◆ Temperature compensation probes attached to batteries

